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A Gardener's Guide to Fertilizing Trees & Shrubs

A GARDENER'S GUIDE to Fertilizing Trees and Shrubs

Fertilizers provide essential nutrients that allow plants to achieve their intended purposes. Properly applied fertilizer helps our trees and shrubs reward us with seasonal color, shade, wildlife habitats, and an improved home appearance and value. Either synthetic (manufactured) and/or natural (organic or inorganic) fertilizers can be used to provide nutrients needed for plant growth.

In forests, decay of leaves and litter continually replaces nutrients taken up by plants. In a home landscape, fallen leaves and litter are commonly removed, resulting in a decline of soil fertility. Also contributing to poor soil fertility is the loss of topsoil by erosion and the use of subsoil for filling and grading during building construction. Subsoil often has poor physical properties, a low pH, and inadequate amounts of essential plant nutrients.

Providing the correct amount and type of fertilizer promotes healthy flower production and foliage growth, while applying too much leads to decline and death. Many gardeners have the false impression that the more they fertilize, the more their trees and shrubs will grow. Fertilizing does not always result in improved plant growth. Fertilizer is not plant food. Plants produce their own food using water, carbon dioxide, nutrients from fertilizer, and energy from the sun. Fertilizers provide nutrients that plants need in modest or small amounts and that may be missing from the soil.

A moderate rate of growth and a moderate green color is desired for most woody plants. Excessive vigor, which is evident by lush, dark green leaves and long shoot growth, is often undesirable. Trees and shrubs growing like this are more susceptible to cold injury, are more likely to be broken during wind and ice storms, and usually require more pruning than plants having moderate growth. In addition, gardeners who fertilize plants that have already outgrown their allotted space will only find themselves pruning more often. Excess fertilizer application increases the likelihood of some plant diseases. Overapplication or incorrect fertilizer application also contributes to pollution of rivers, streams, lakes, and estuaries.

Plant nutrients

Plants require 17 nutrients for normal growth. They draw carbon, hydrogen, and oxygen from the air and water. They absorb nitrogen, potassium, magnesium, calcium, phosphorus, and sulfur from the soil. These last six elements are used in relatively large amounts by the plant and are called macronutrients. Eight other elements are absorbed from the soil but are used in much smaller amounts. They are called micronutrients or trace elements. The micronutrients include iron, zinc, molybdenum, manganese, boron, copper, cobalt, and chlorine. The nutrients that are most likely to limit plant growth are nitrogen, phosphorus, and potassium.

Nitrogen (N) is a primary component of proteins and is part of every living cell. This nutrient is usually more

CAUSES OF POOR PLANT GROWTH

Trees and shrubs that are growing poorly exhibit one or more of the following symptoms:

- Light green or yellow leaves.
- Leaves with dead spots.
- Smaller than normal leaves.
- Fewer leaves and/or flowers than normal.
- Short twig growth.
- Dying back of branches at the tips.
- Wilting foliage.

Poor growth symptoms may be caused by inadequate soil aeration or moisture, adverse climatic conditions, improper pH, nutrient toxicity or deficiencies, or disease. Recently transplanted trees and shrubs often will not resume a normal growth rate until their root systems become established. Plants disturbed by construction within the past 5 to 10 years may be in shock and produce limited new foliage. First, determine why your plant is growing poorly, then try to correct all factors contributing to poor growth. Fertilization may be helpful, but only after you correct problems causing poor growth.

responsible for increasing plant growth than any other nutrient. Shortages can cause slow growth, smaller leaves, yellowing, short branches, and premature fall color and leaf drop, and can increase the likelihood of some diseases. An overabundance of nitrogen can cause excessive shoot and foliage growth, reduced root growth, low plant food reserves, and increased susceptibility to environmental stresses and some diseases.

Nitrogen is found in many different forms—it is in constant motion. Nitrogen applied to the soil can be used by plants, washed off the soil surface, lost to the air as a gas, or leached through the soil. Nitrogen loss is higher when a heavy rain immediately follows a surface application of fertilizer, especially on sloped areas. Incorporating fertilizer into the soil or lightly watering (1/4 to 1/2 inch) after making a surface application will reduce nitrogen loss. Do not apply fertilizer when the foliage is wet after a rain or irrigation because it will burn the leaves.

Phosphorus (P) plays a role in photosynthesis, respiration, energy storage and transfer, cell division, and cell enlargement. It promotes early root formation and growth and the production of flowers, fruits, and seeds. Many urban soils are low in phosphorus. Previously cultivated farmland or garden sites often have a high phosphorus level from years of fertilization. In these cases, adding more phosphorus will not increase yields and, in fact, may harm the environment. High levels of phosphorus in the soil make other nutrients, such as iron, unavailable and may result in discolored leaves and poor growth.

When applied as fertilizer, phosphorus is quickly bound by soil particles. Phosphorus is extremely immobile in soils (except sand and organic matter); it only moves about 1 inch from its original placement. Unless phosphorus is incorporated into the soil, watered in, or applied as a band, plants may not be able to use it.

Potassium (K) is involved in many plant growth processes; it is vital to photosynthesis and helps regulate water levels in plants. Potassium fertilization helps plants overcome drought stress, increases disease resistance, and improves winter hardiness. Potassium can be leached through the soil by water, but not as quickly as nitrogen.

NUTRIENT UPTAKE BY PLANTS

Nutrients in the soil can be in a solid form (granular fertilizer, organic matter), attached to the soil particles, or dissolved in soil water. For a nutrient to be absorbed by plants, it must be in a form the plant can use and be dissolved in the soil water. Water and oxygen are required for nutrients to move into plant roots.

Anything that inhibits sugar production in leaves can lower nutrient absorption. If the tree or shrub is under stress due to low light or extreme temperatures, it may develop nutrient deficiency problems even though adequate nutrients are available in the soil solution. Diseased or damaged roots, improper soil pH, waterlogged sites, and plantings that are too deep can result in inefficient nutrient absorption. Adding fertilizer under these conditions will not enhance growth and may damage plants.

The level of nutrient absorption may also be affected by the stage of growth or how actively a tree or shrub is growing. Many plants go into a rest period, or dormancy, during part of the year and absorb few nutrients.

Types of fertilizers

Synthetic fertilizers

All fertilizers are labeled with three numbers: the percentage (by weight) of nitrogen (N), phosphorus (P) in the form of phosphate (P_2O_5), and potassium (K) in the form of potassium oxide (K_2O). A 50-pound bag of fertilizer labeled 0-20-10 has zero pounds of nitrogen, 10 pounds of P_2O_5, 5 pounds of K_2O, and 35 pounds of filler. Filler is added to make the fertilizer easier to spread and to reduce the likelihood of burning plants with too much fertilizer. A fertilizer may contain secondary nutrients or micronutrients not listed on the label.

The diversity of fertilizer types and brands can be overwhelming. But one crucial factor to consider is the type of nitrogen, which is directly related to water quality. Most fertilizers contain nitrogen in a quick-release form (10-10-10 and 8-8-8); others come in a slow-release form (16-4-8, 12-4-8), and some are a combination of both. Quick-release fertilizers are immediately available, but do not last as long as other forms and can damage plants if a large amount is applied.

Ammonium nitrate, ammonium sulfate, calcium nitrate, and potassium nitrate are water-soluble, quick-release forms of nitrogen. Excessive applications of a quick-release fertilizer can worsen soluble salt problems, which can burn or kill plant roots. Nitrogen in quick-release fertilizer becomes available as soon as it contacts soil water. Urea is an organic form of nitrogen but is quickly converted to ammonium nitrogen, then to nitrate nitrogen. High application rates combined with heavy irrigation or rainfall can result in large amounts of nitrogen leaching below the root zone.

Slow-release or controlled-release fertilizers release nutrients slowly, making them available to trees and shrubs over a long period. They do not need to be applied as frequently as other fertilizers. Thus, there is less risk of slow-release or controlled-release fertilizers leaching into groundwater. The cost per pound is usually four to five times more than for quick-release fertilizers.

The initials WIN and WSN on fertilizer labels stand for water-insoluble nitrogen and water-soluble nitrogen, respectively. Water-soluble nitrogen dissolves readily and is usually in a simple form, such as ammonia nitrogen or nitrate nitrogen. Water-insoluble nitrogen is referred to as a slow-release nitrogen source. It is usually an organic form of nitrogen (with the exception of urea) that must be broken down into simpler forms by soil microorganisms before it can be used.

Sulfur-coated urea is a slow-release fertilizer with a covering of sulfur around each urea particle. The thickness of the sulfur coating controls the rate of nitrogen release, not watering. Sulfur-coated urea applied to the soil surface releases nitrogen more slowly than when incorporated into the soil. This material generally costs less than other slow-release fertilizers, and it supplies the essential element sulfur.

Some fertilizer products are coated with layers of resin or plastic. When resin coatings come into contact with water, the layers swell and increase the pore size of the resin so that the dissolved fertilizer can move into the soil. Plastic coatings generally contain pores, which are filled with waxes that deteriorate and allow nutrients to be released. Release rates for controlled-release and slow-release fertilizers depend on the coating thickness, temperature, and water content of the soil. There is often a large release of fertilizer during the first 2 or 3 days after application. Full release can take up to 12 months, depending on the coating.

Table 1. Nutrient content of natural materials

Materials	*% Nitrogen (N)*	*% Phosphate (P)*	*% Potash (K)*
Ashes, unleached	0	2.0	6.0
Ashes, leached	0	1.2	2.0
Blood (dried)	12 to 15	3	0.6
Bone meal, raw	3.5	22	-
Bone meal, steamed	2.2	28	0.2
Coffee grounds	2.1	0.3	0.3
Compost	0.3	0.2	0.4
Cottonseed meal	6 to 7	2.5	1.5
Greensand	-	1 to 2	5.0
Hair	12 to 16	-	-
Kelp or seaweed	1.5	1.0	4.9
Lawn clippings	1.2	0.3	2.0
Peanut hull meal	1.2	0.5	0.8
Oyster shells	0.2	0.3	0.03
Sawdust, wood shavings	0.2	-	0.2
Sewage sludge	2.6	3.7	0.2
Sewage sludge, activated	6.0	3.0	0.2

Natural fertilizers

Natural materials such as compost, manure, bone meal, and cottonseed meal can be effective fertilizers (Table 1, Table 2). Plants absorb most elements as inorganic ions. Organic forms must be converted to inorganic ions before root uptake occurs. Most natural fertilizers release their nutrients more slowly than synthetic fertilizers because the organic material must be decomposed into inorganic nutrients. The rate of decomposition is affected by temperature, moisture, and soil composition. Natural materials improve soil organic matter content, which may include soil tilth, or its suitability for planting.

Liquid fertilizers

Liquid fertilizers work the same as granular fertilizers. They are a concentrated liquid or powder that is mixed with water and applied to the soil or sprayed on the foliage of a tree or shrub. They normally cost more per pound of nutrient than granular forms of fertilizer. Their release rate is rapid, but they have a very short residual effect and must be applied often.

Foliar applications may be needed to supply a plant with micronutrients, such as iron or zinc. If soil pH is very low or if the phosphorus level is very high, soil micronutrients may be unavailable to plant roots. If the foliar nutrient solution is too strong, leaf

Table 2. Nutrient content of manures			
Manures	*% Nitrogen (N)*	*% Phosphate (P)*	*% Potash (K)*
Bat	6.0	9.0	3.0
Beef (fresh)	0.6	0.4	0.5
Beef (dry)	1.2	2.0	2.1
Chicken (fresh)	0.9	0.5	0.5
Chicken (dry)	1.6	1.8	2.0
Hog (fresh)	0.6	0.3	0.4
Hog (dry)	2.2	2.1	1.0
Horse (fresh)	0.6	0.3	0.5
Rabbit (fresh)	2.4	1.4	0.6
Turkey (fresh)	1.3	0.7	0.5

burn is likely. Always follow the manufacturer's recommendations. Trees and shrubs growing in containers might best be treated with a liquid houseplant fertilizer instead of a granular form.

One fertilization method that should be used only as a last resort is tree injections of liquid micronutrients. Drilling holes can permanently injure trees, and the decay that could develop may outweigh any temporary benefit the fertilizer may provide. This practice may seem beneficial at first because the tree will respond to the fertilizer. But decay often develops slowly, and it may be years before the damage becomes obvious.

Specialty fertilizers

There are a number of fertilizers on the market that are intended for use with a specific shrub type, such as roses, hollies, or camellias. These fertilizers work well, but they cost more per pound of nutrient than most nonspecialty fertilizers. If the soil pH is in the proper range, a conventional fertilizer will work just as well as specialty fertilizer and cost less.

Fertilizer spikes and stakes that are driven into the ground contain satisfactory amounts of nutrients. Unfortunately, very little fertilizer comes into contact with most of the root system because of the spike spacing. Lateral fertilizer movement in the soil is very limited.

Do not use weed-and-feed fertilizers under trees or shrubs unless the label says it is safe. Some plants, such as dogwoods, are very sensitive to dicamba herbicide, which is contained in many weed-and-feed lawn fertilizers.

Table 3. Recommended application rate for various granular fertilizers to apply 1 pound of nitrogen					
Application rates per:					
	1,000 Square Feet		100 Square Feet		10 Square Feet
Source	*Pounds*	*Cups*	*Pounds*	*Cups*	*Tablespoons*
10-10-10	10	20	1	2	4
8-8-8	12.5	25	1.2	2.5	5
12-4-8	8	16	.75	1.5	3
16-4-8	6	12	.5	1	2
5-10-10	20	40	2	4	8
12-6-6	8	16	.75	1.5	3

Fertilizing newly installed trees and shrubs

Wait until spring to fertilize fall-planted trees and shrubs. Wait 6 to 8 weeks to fertilize plants installed in the spring. Apply a slow-release fertilizer in a light band along the perimeter of the planting hole. Remember that newly installed trees and shrubs are under stress and should receive only a light application of fertilizer. Apply 1 level teaspoon of a high nitrogen fertilizer such as 16-4-8 or 1 level tablespoon of 10-10-10 fertilizer for 1-gallon container plants. Apply 2 to 3 level tablespoons for larger plants.

Fertilizing established trees and shrubs

Base your fertilization rates on soil test results, plant age, current and desired growth rate, and plant type, or use the general guidelines on page 7. You also should consider rainfall and soil type. You may need to apply more fertilizer during wet seasons, especially in sandy soils, and less during dry weather. Fertilizer increases water demand for new growth and can injure roots of ornamentals under drought stress.

Soil test—The best answer to how much fertilizer to apply is to use the amount recommended by a soil test report. Have the soil tested before planting and every 2 to 3 years thereafter. The North Carolina Department

Table 4. Rates for converting a pound of fertilizer to approximate volumes

Fertilizer	*Cups per pound*	*Tablespoons per pound*
Ground limestone	1 1/2	24
Nitrate of soda	1 1/2	24
Potassium sulfate	1 1/2	24
Calcium nitrate	2	32
Superphosphate	2 1/4	36
10-10-10	2 1/4	36
5-10-10	2 1/2	36
Ammonium nitrate	2 1/2	40
Epsom salts ($MgSO_4$)	2 1/2	40
Aluminum sulfate	2 3/4	44
Hydrated lime	4	64

of Agriculture and Consumer Services Agronomic Division, 5300 Reedy Creek Road, Raleigh, NC 27607-6465, analyzes soil samples free of charge. You can submit samples to the lab or through your county Extension center. Information on soil pH, suggested lime, and fertilizer grade and rate will be mailed to you, or you can find the results on the Internet at http://www.agr.state.nc.us/agronomi/pals.htm

The soil test report provides recommendations for pounds of lime and a rate and grade of fertilizer per 1,000 square feet. Many home gardeners have difficulty determining how much fertilizer to use even when they know the recommended rate and the size of the area. Table 3 can be used to determine the amount to apply for small areas. Table 4 provides information on converting a pound of fertilizer to cups or tablespoons.

Growth rate—Although soil test results are most accurate, the amount of new growth on trees and shrubs can be used as a guide to determine fertilizer needs. Growth rates vary among different species and cultivars and from season to season. Generally, young, healthy trees produce about 9 to 12 inches of terminal growth each year. Large, mature trees average 6 to 9 inches of annual growth. The amount of growth for the current season can be measured from the tip of the shoot to the first ring of annual bud scars, which are the points where shoot growth stopped the previous year (Figure 1). Fertilizer is normally not required when new shoots grow more than 6 inches in one season. When new shoot growth is between 2 and 6 inches, fertilizer is optional. Plants may need additional fertilizer if they have poorly colored leaves, smaller than normal leaves, or premature fall color or leaf drop. These signs may also indicate some type of root problem. Deficiency symptoms do not indicate how much fertilizer is needed—only that fertilizer is needed.

Age/size—Give newly installed trees and shrubs time to establish their root system before trying to push new growth with high-nitrogen fertilizer. This is especially true for ball-and-burlapped or bare-root plants. Usually it's best not to fertilize the first season after transplanting. When trying to push the growth of a young hedge, make several light applications of fertilizer per year (March, May, July). As woody plants mature, they need less nitrogen; rapid growth is no longer needed or desired. Most established woody plants perform well with just one fertilizer application per year or perhaps every other year.

Type of plant/location—Plants growing in a restricted root zone need less nitrogen than other plants. Fertilizer can easily damage plants with a fibrous root system, such as azalea, rhododendron, and blueberry. Light applications are recommended. Plant roots normally grow three times as far as their branches. Ornamentals located near a lawn that is fertilized regularly may not need additional fertilizer since many of their roots extend into the lawn area where they will absorb nutrients.

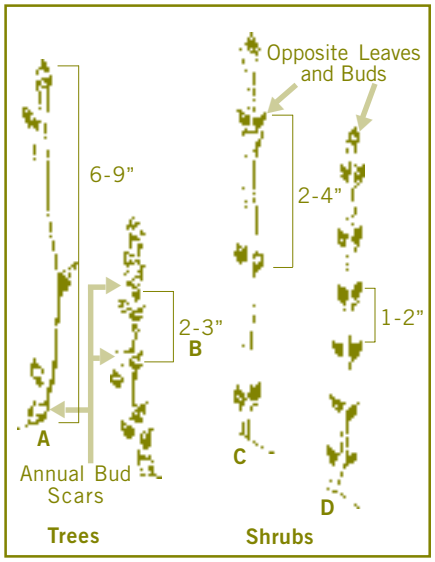

Figure 1. Most young trees should grow an average of 9 to 12 inches or more per year. Vigor is determined by the differences between annual bud scars (A & B). Six to nine inches is good growth for established trees. Less than 6 inches annual growth for a tree may indicate a need for fertilizer (B).

Annual bud scars may be harder to find on a shrub, but distance between leaf buds is an indication of vigor (C & D). Shrub sizes vary, so distance between leaf buds must be considered for the type of shrub.

Evergreen trees and shrubs appear to require lower rates of nutrients than deciduous plants. Overfertilized conifer trees often develop open growth with widely spaced branches. Narrow-leaf evergreen shrubs need only enough fertilizer to maintain moderate green color.

General guidelines—If you have not taken a soil test, you may want to follow some general guidelines. Normally, 2 to 4 pounds of a complete fertilizer such as 10-10-10 per 1,000 square feet are recommended each year for optimum growth. Use the higher rate when trying to push new growth. To determine how much of a particular fertilizer to apply, divide the percentage nitrogen into 100 and multiply by the amount of nitrogen recommended. For example, the amount of 12-4-8 fertilizer needed to apply 1 pound of actual nitrogen per 1,000 square feet is obtained by dividing 100 by 12 and multiplying by 1. Thus 8.3 pounds of 12-4-8 fertilizer should be applied per 1,000 square feet. Table 5 can be used to determine how much fertilizer is needed to supply various amounts of nitrogen per 1,000 square feet.

For small trees and shrubs, use 1/2 cup of 8-8-8 fertilizer per square yard of area covered by plant foliage. The amount of fertilizer used should not exceed 1 tablespoon per foot of plant height for fertilizers containing 10 percent nitrogen or more. Do not apply more than 1 pound of actual nitrogen per 330 square feet. For large trees, measure the diameter 4 feet from the ground and apply 0.1 pound actual nitrogen (0.1 pound of actual nitrogen equals 1 pound of 10-10-10, 0.3 pound of ammonium nitrate [33-0-0], or 0.2 pound of 5-10-10) for each inch of trunk diameter. If the area under the tree is known, simply broadcast 0.1 pound of actual nitrogen per 100 square feet. An alternative is to apply 1 to 2 pounds of a complete fertilizer per inch of trunk diameter. Trees less than 6 inches in diameter need about 2 pounds of fertilizer.

Unless a soil test indicates otherwise, use a fertilizer containing 10 to 16 percent nitrogen. Fertilizers such as 16-4-8 and 12-4-8 have the ideal ratio for woody plants; however, fertilizers such as 10-10-10 or 8-8-8 can be used. At least 30 percent of the nitrogen should be in the ammoniacal or urea form. They release nitrogen more slowly than those in a nitrate form.

Time and method of application

Generally, the timing and rate of fertilizer application are more critical than the type you purchase. Nitrogen fertilizer applications have their greatest effect 3 to 4 weeks after they are applied. Woody plants can absorb nutrients as long as the soil temperature is above 40°F. Roots grow during cool weather even when the foliage appears dormant. Woody ornamental roots grow most in fall and late winter/early spring and less during hot, summer weather.

Fertilize trees and shrubs in the spring or fall. Make spring fertilizer applications in February or March before new growth begins. Make fall applications about 1 month after the first killing frost. Fertilizer applied in the fall is more effective in promoting plant growth than spring-applied fertilizer. But bear in mind that unseasonably warm winter weather could damage trees and shrubs that have been fertilized in the fall. Environmentally, early spring is the best time to fertilize because it avoids leaching during the winter.

Avoid fertilization in late summer (mid-August) since it may stimulate late-season growth that fails to harden off before frost. Do not use slow-release fertilizers after July 15.

Spread the fertilizer evenly over the entire root zone, which extends two to three times the span of the branches

Table 5. Pounds of fertilizer needed per 1,000 square feet to supply various amounts of actual nitrogen

N-P-K	*1 Pound*	*1¼ Pounds*	*1½ Pounds*	*3 Pounds*
45-0-0 (urea)	2.2	2.7	3.3	6.5
33-0-0 (ammonium nitrate)	3	3.7	4.5	9.1
27-7-7	3.7	4.6	5.6	11.1
21-0-0 (ammonium sulfate)	4.8	5.9	7.1	14.3
20-20-20	5	6.2	7.5	15
16-4-8, 16-8-8	6.2	7.8	9.4	18.8
15-5-5	6.7	8.3	10	20
12-4-8	8.3	10.4	12.5	25
10-10-10	10	12.5	15	30
5-10-10, 5-10-5	20	25	30	60

Figure 2. Apply fertilizer to the surface of mulched and unmulched areas extending out from the tree or shrub's trunk up to three times the spread of the branches.

(Figure 2). Keep fertilizer off the stems of shrubs and at least 1 foot away from tree trunks. Remember that some of the root zone may have already been fertilized when fertilizer was applied to the lawn or flower bed. Sprinkle the fertilizer on top of the soil or mulch and water lightly. The fertilizer will quickly move through the mulch, so there is no need to remove it or to place the fertilizer below it. Spread the fertilizer evenly under the branches. Dumping fertilizer in one spot can damage the roots below. A shaker jar, which is a jar with small holes in the cover, can be helpful. Apply fertilizer when the foliage is dry so the fertilizer does not stick to plant foliage and cause burning. Use a broom to brush fertilizer off plant foliage that lodges in whorls. Sweep up any fertilizer that lands on driveways or walks and may be washed into gutters, ditches, or storm drains.

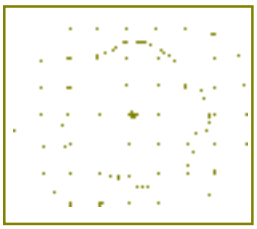

Figure 3. If the soil is compacted, you can fertilize trees and shrubs by drilling evenly spaced holes under and slightly beyond the drip line (the outer edges of the branches).

The practice of placing fertilizer in holes around mature trees has been tested, and research indicates surface application of fertilizer is sufficient since most of the feeder roots are in the top foot of soil. If the soil is compacted, you can bore holes 4 to 6 inches deep, 2 to 3 feet apart, using a punchbar or a drill with a 2-inch auger (Figure 3). Start 4 feet from the trunk and continue to 2 feet beyond the branches. Bore the holes about 5 feet apart in a circular pattern with each circle about 4 feet farther out than the previous circle. Divide the fertilizer into as many equal parts as there are holes and place in the holes. But do not put more than a handful of fertilizer in each hole. Boring holes in soil can increase soil aeration and water penetration into the root zone.

Additional information

A Gardener's Guide to Protecting Water Quality AG-612

Composting: A Guide to Managing Organic Yard Wastes AG-467

A Gardener's Guide to Soil Testing AG-614

Internet resources

Managing Lawns and Gardens to Protect Water Quality AG-439-21 http://www.bae.ncsu.edu/programs/extension/publicat/wqwm/ag439_21.html

Compost/mulch
http://www.ces.ncsu.edu/depts/hort/consumer/hortinternet/compost_mulch.html

Organic
http://www.ces.ncsu.edu/depts/hort/consumer/hortinternet/organic.html

Soils/fertilizer
http://www.ces.ncsu.edu/depts/hort/consumer/hortinternet/soils.html

Fertilizer Recommendations and Techniques to Maintain Landscapes and Protect Water Quality AG-508-5
http://www.bae.ncsu.edu/programs/extension/publicat/wqwm/wqwm127.html

General horticulture
http://www.ces.ncsu.edu/depts/hort/consumer/

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